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(54) Method for forming photoresist pattern

(57) A method for forming photoresist patterns, comprising the steps of: coating a photoresist containing a photosensitive acid generator 3 on a support 1 forming a silicon monomer layer 2 on the photoresist 2; exposing the monomer layer to light through a mask 4 to selectively polymerize the silicon monomer; removing the unexposed regions of the monomer layer and subjecting the remaining polymerized regions 5 to oxygen plasma to form silicon oxide layer 7 and imagewise exposing photoresist 3 to deep UV, X-ray or electron beams and developing to produce photoresist pattern 3 with said oxide layer 7 serving as a mask. Exposure of the photosensitive acid generator generates protons which trigger the polymerization of silicon monomers. The silicon oxide layer 7 subsequentially formed is not removed by typical developing solutions and serves as a mask to expose the photoresist film 3.

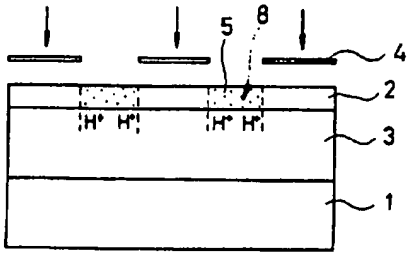

Fig. 2A

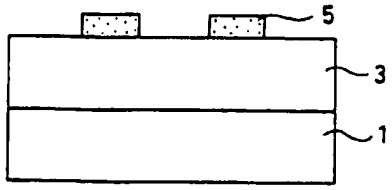

Fig. 2B

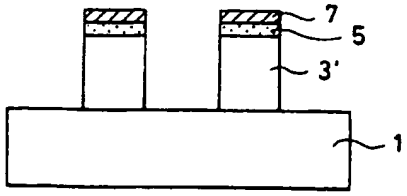

Fig. 2C

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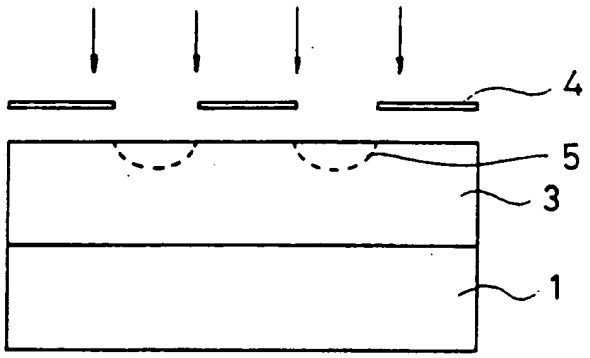


Fig. 1A

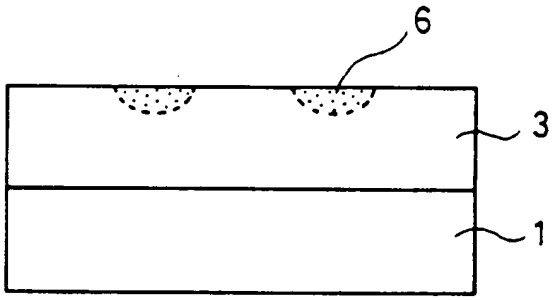


Fig. 1B

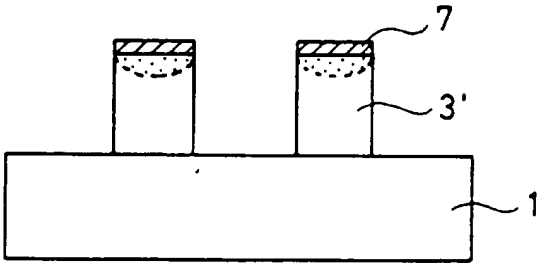


Fig. 1C

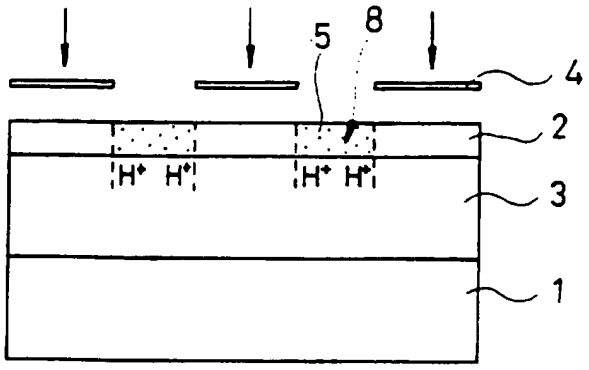


Fig. 2A

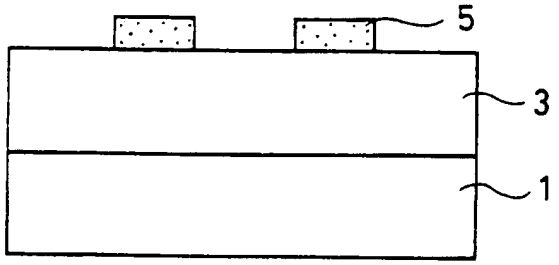


Fig. 2B

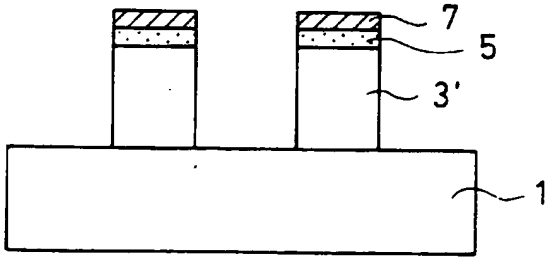


Fig. 2C

(a) $CR = \underset{\displaystyle Si(OR)_3}{\overset{\displaystyle CR}{|}}$

(b) $R - O - \underset{\displaystyle R}{\overset{\displaystyle R}{\overset{|}{Si}}} - OR$

Fig. 3

(a) $H^+ + CR_2 = \underset{\displaystyle Si(OR)_3}{\overset{\displaystyle CR}{|}} \longrightarrow \left\{ CR - \underset{\displaystyle Si(OR)_3}{\overset{\displaystyle CR}{|}} \right\}_n$

(b) $H^+ + R - O - \underset{\displaystyle R}{\overset{\displaystyle R}{\overset{|}{Si}}} - OR \longrightarrow \left\{ O - \underset{\displaystyle R}{\overset{\displaystyle R}{\overset{|}{Si}}} \right\}_n$

Fig. 4

METHOD FOR FORMING PHOTORESIST PATTERN

BACKGROUND OF THE INVENTION

Field of the Invention

The present invention relates, in general, to a method for forming photoresist patterns and, more particularly, to a simple diffusion enhanced silylated resist (hereinafter referred to as "DESIRE") method in which silicon injection processing is unnecessary.

Description of the Prior Art

In order to better understand the background of the invention, a description of a conventional method utilizing DESIRE processing will be given below, in connection with Fig. 1.

Fig. 1A is a cross sectional view after a chemically enhanced photoresist 3 coated on a lower layer 1 was exposed to light through a mask 4, to form exposed regions 5.

Fig. 1B is a cross sectional view after silicon was injected into the exposed regions 5 by a silylation process, to form silylated resist regions 6.

Fig. 1C is a cross sectional view after an oxygen plasma development process was carried out to form silicon oxide films 7 through the reaction of oxygen with the silicon of the silylated resist regions 6 and to form photoresist patterns 3' through etch of the unexposed regions of the photoresist 3, simultaneously.

A significant problem of this conventional DESIRE method is that critical dimension is changed, which is attributed to the fact that hydrolysis arises owing to the delay time between processes, causing the out-diffusion of silicon. And, this conventional

method is problematic in pattern substantiality. That is, swelling occurs when using tetramethyl disilazane (TMDS), a compound comprising dimethyl silicon or hexamethyl disilazane (HMDS), a compound comprising trimethyl silicon because of bulkiness of the compounds. As a result, pattern deformation occurs.

SUMMARY OF THE INVENTION

Accordingly, it is a principal object of the present invention to overcome the above problems encountered in prior art and to provide a simple method for forming photoresist patterns, which is capable of showing the effect of silicon injection without silicon injection process.

Based on intensive and thorough research by the present inventors, the above object could be accomplished by providing a method for forming photoresist patterns, comprising the steps of: coating a chemically enhanced photoresist film on a lower layer; forming a silicon monomer layer on the chemically enhanced photoresist film; exposing the monomer layer to light through a mask, to selectively polymerize the silicon monomer; removing the unexposed regions of the monomer layer by development; and subjecting the remaining polymerized regions to oxygen plasma developing process to form oxide films through reaction of oxygen with the silicon contained in the polymerized regions and to form photoresist patterns through selective etch of the photoresist film, with said oxide films serving as a mask.

According to the present invention, exposure of silicon monomers generates protons from the chemical enhanced photoresist film which trigger the polymerization of silicon monomers. The polymer thus formed is not removed by typical developing solutions and serves as a mask when etching the photoresist film with oxygen plasma because a thin silicon oxide (SiO_2) is formed on the

polymer, which contains silicon.

BRIEF DESCRIPTION OF THE DRAWINGS

The above object and other advantages of the present invention will become more apparent by describing in detail the preferred embodiments of the present invention with reference to the attached drawings in which:

Figs. 1A to 1C are schematic cross sectional views showing a conventional DESIRE method for forming photoresist film patterns;

Figs. 2A to 2C are schematic cross sectional views showing a DESIRE method for forming photoresist film patterns, according to the present invention;

Figs. 3A and 3B show structural formulas of silicon monomers useful in the present invention; and

Figs. 4A and 4B show structural formulas of the polymers which are formed from the silicon monomers of Fig. 3A and 3B, respectively.

DETAILED DESCRIPTION OF THE INVENTION

The application of the preferred embodiments of the present invention is best understood with reference to the accompanying drawings, wherein like reference numerals are used for like and corresponding parts, respectively.

Referring to Fig. 2, there is illustrated a method for forming photoresist patterns according to the present invention.

First, Fig. 2A is a schematic cross section after a silicon monomer layer 2 is formed on a chemically enhanced photoresist film 3 coated on a lower layer 1, followed by exposure of the monomer layer to light through a mask 4, to change the exposed regions of the monomer layer 2 into polymeric films 7 containing silicon.

This polymer results from the polymerization of the silicon monomers themselves, which is triggered by acid (H^+). H^+ is generated by a photo acid generator contained in the photoresist film 3 upon exposure.

Fig. 2B is a cross section after a developing process using a typical solution is carried out to remove the unexposed monomer regions 2 while leaving the polymeric regions 5.

Fig. 2C is a cross section after the resulting structure of Fig. 2B is subjected to oxygen plasma development, to form silicon oxide layers 7 through the reaction of oxygen with silicon contained in the polymer 5 and to form photoresist patterns 3' through the selective etch of the photoresist film 3 with the silicon oxide layers 7 serving as a mask.

Deep ultra violet, electron beams or X-rays can be used for exposing the chemically enhanced photoresist film. Although only negative type is stated, the present invention can be applied to a positive type.

Referring to Fig. 3, molecular structures of the silicon monomers used for the invention are shown. In the molecular structures, R represents an alkyl or aryl.

Referring to Fig. 4, there are formulas showing the polymerization of the silicon monomers of Fig. 3.

The aforementioned problems of the conventional DESIRE method, that is, the unstable critical dimension which is caused by the out-diffusion of silicon attributable to hydrolysis because of the time delay between processes allows water to be formed, and corresponding poor pattern substantiality, can be solved by the present invention. In addition, the method according to the

present invention exhibits the effect of silicon injection without silicon injection process.

Other features, advantages and embodiments of the invention disclosed herein will be readily apparent to those exercising ordinary skill after reading the foregoing disclosures. In this regard, while specific embodiments of the invention have been described in considerable detail, variations and modifications of these embodiments can be effected without departing from the spirit and scope of the invention as described and claimed.

CLAIMS:

1. A method for forming photoresist patterns, comprising the steps of:

coating a chemically enhanced photoresist film on a lower layer;

forming a silicon monomer layer on the chemically enhanced photoresist film;

exposing the monomer layer to light through a mask, to selectively polymerize the silicon monomer;

removing the unexposed regions of the monomer layer by development; and

subjecting the remaining polymerized regions to oxygen plasma developing process to form oxide films through reaction of oxygen with the silicon contained in the polymerized regions and to form photoresist patterns through selective etch of the photoresist film, with said oxide films serving as a mask.

2. A method in accordance with claim 1, wherein said chemically enhanced photoresist film is exposed to deep ultra violet, electron beam or X-ray.

3. A method in accordance with claim 1 or 2, wherein said chemically enhanced photoresist film is of negative or positive type.

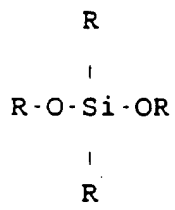
4. A method as set forth in any one of the preceding claims, wherein said silicon monomer has a structure represented by the following formula:

$$CR_2 = CR$$

$$Si(OR)$$

in which, R represents an alkyl or aryl.

5. A method as set forth in any one of the preceding claims, wherein said silicon monomer has a structure represented by the following formula:



in which, R represents an alkyl or aryl.

6. A method as set forth in any one of the preceding claims, wherein the polymerization of said silicon monomers is triggered by proton which is generated by photo acid generator contained in said photoresist film upon exposure.

7. A method for forming photoresist patterns substantially as hereinbefore described with respect to any one of Figs. 2A - 4 of the accompanying drawings.

Patents Act 1977 Examiner's report to the Comptroller under Section 17 (The Search report)	Application number GB 9520610.8
Relevant Technical Fields (i) UK Cl (Ed.N) G2C (CRN, CRT3, CRX) (ii) Int Cl (Ed.6) G03F	Search Examiner MR M REYNOLDS Date of completion of Search 9 NOVEMBER 1995
Databases (see below) (i) UK Patent Office collections of GB, EP, WO and US patent specifications. (ii)	Documents considered relevant following a search in respect of Claims :- 1-7

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E: Patent document published on or after, but with priority date earlier than, the filing date of the present application.

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Category	Identity of document and relevant passages	Relevant to claim(s)
	NONE	

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